Environmental Database Support for the Navy Using CORBA

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The Navy Tactical Environmental Support System Next Century (TESS(NC)) collects, p analyzes, displays and disseminates METeorological and OCeanographic (METOC) products. TESS provides the METOC community with the tools necessary to view dimensional atmosphere and ocean environments over time. In addition, tailored METOC and data are sent to on-scene decision-makers (warfighters) so they can run their own appli interpret the impact of the METOC environment on operations.

TESS relies on the Tactical Environmental Data Server (TEDS) RDBMS (relational management system) and operates in a heterogeneous network environment. TEDS is imp using Informix in a client-server mode. The TESS(NC) Concept of Operations an architecture require that the METOC Database be distributed both in terms of application METOC data and products (API segments) and in terms of physical location of the data re (Data segments). RemoteTEDS is a software library, interchangeable with the existing TED to provide applications access to the TEDS database. RemoteTEDS uses CORBA to impl TEDS APIs across a computer network (TCP/IP).

This paper will summarize the experiences of Naval Research Laboratory, Monterey, Cal implementing RemoteTEDS in a prototype demonstration, the Tactical Atmospheric System/Real-Time (TAMS/RT).

INTRODUCTION TO TESS AND TEDS

The Navy Tactical Environmental Support System Next Century (TESS(NC)) supp ships and shore sites and interfaces with a variety of Navy Command and Control, Commu and Computers, and Intelligence (C4I) systems. The NITES (Navy Integrated Tactical Envir Subsystem) Version I provides the METOC community with the tools necessary to view dimensional atmosphere and ocean environments, manipulate the data, and use their pre training to produce value-added products in support of the on-scene commander. The N version provides on-scene operational decision-makers, i.e., the warfighters, with the ability tailored METOC products within the tactical arena so that the operational decision-maker ca interpret the direct impact of the METOC environment on warfare operations. NITES II al Tactical Decision Aids (TDAs) within the C4I architecture access to required METOC data. III is tailored to aviation support. NITES IV provides mobile support for tactical users. NI for foreign military sales.

The Tactical Environmental Data Server (TEDS) is a RDBMS (relational database management system) developed specifically for the Navy to provide weather-related data to applications. TEDS operates in a heterogeneous network environment and manages environmental data and products to support analyses and applications that serve tactical end users. TEDS was originally developed using EMPRESS, but is currently implemented using Informix in a client-server mode. (TEDS schema can easily be ported to other RDBMS's such as Oracle or Sybase.) TEDS supports a single, logical access point for multiple, physically distributed databases. It supports transparent access to the database from any member node. Environmental data and products are managed as objects. TEDS provides an Applications Programming Interface (API) "layer" for each data type that serves as the interface between the database and clients. The data set organization provides the structure and functions for applications to determine what is contained in the database, and an API for managing data sets.

In accordance with the Department of Defense DII COE (Defense Information Infrastructure Common Operating Environment) and SHADE (Shared Data Environment) concepts, the METOC Database is composed of six DII COE compliant *shared database* segments. Associated with each shared database segment is an API segment. The segments are arranged by data type as follows:

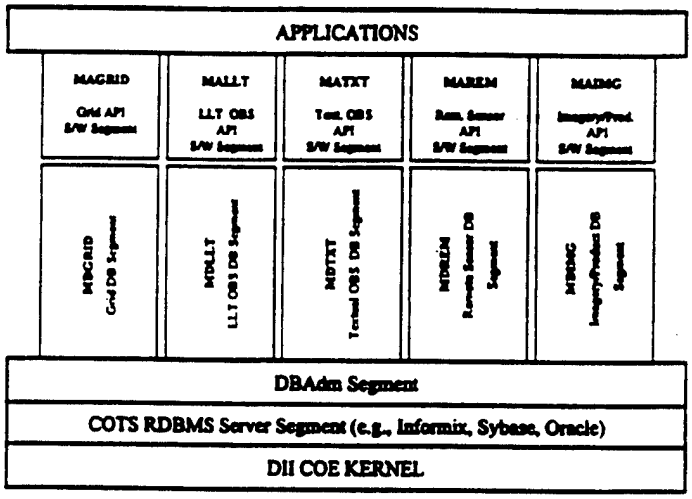
Data Type	Data Segment	API Segment
Grid Fields	MDGRID	MAGRID
Latitude-longitude-time (LLT) Observations	MDLLT	MALLT
Textual Observations and Bulletins	MDTXT	MATXT
Remotely Sensed Data	MDREM	MAREM
Imagery and Product Data	MDIMG	MAIMG
Climatology Data	MDCLIM	MACLIM

In a typical client-server architecture, the shared database segments reside on a DII COE SHADE database server, with a NITES I or II client machine hosting the API segments. Communication between API segments and shared database segments is accomplished over the network using ANSI-standard Structured Query Language (SQL).

Grid Field METOC data sets provide forecast information for various atmospheric and oceanographic parameters. A data set represents a logical collection of discrete grid field data records. The grid data records are each logically organized according to grid model type and base time. A grid data record contains descriptive information (element, level, forecast period, etc.) and the actual grid values. Grid Fields are received in GRIB (Gridded Binary) message format. Grid data can be associated with a specific geographic area, parameter, level, model and forecast period and are typically displayed as contours or plots by a client application. Data are regularly spaced values of specific environmental

parameters (temperature, pressure, wind speed, wind direction, sea surface temperature, etc.) as predicted by numerical forecast models. Grid Field data managed by TEDS includes separate grids for specific parameters at analysis and forecast time periods (0, 12, 24... hours in the future), and differing model resolutions (grid size and geographical coverage).

TEDS Segments



LLT data are point observations. These include surface weather observations, synoptic observations, METAR reports, Terminal Aerodrome Forecasts (TAFs), upper air observations (e.g., radiosonde reports, aircraft observations), and ocean soundings (bathythermograph, sound velocity profiles, etc.). Note that Grid Field Data are regularly spaced, whereas LLT data are not.

Textual Observation data are primarily ASCII formatted forecasts or bulletin/warning messages. Textual observation data can be associated with a specific geographic point and time, but more generally are associated with a geographical area or region. Types include Forecast Reports, Warnings, and Notices. Depending on the type of textual observation, the reporting station or organization, and the area or region affected, a textual observation may be decoded and stored along with the textual portion of the message. Textual observation data are typically displayed as text by a client application.

Remotely Sensed Observational Data are observations derived from specific sensors on DMSP, TIROS, GOES, and other remote ocean sensing systems satellites. These data sets are earth-locatable and reported as individual satellite sensor readouts. Generally, these observations are recorded and associated with a track, profile, or swath of individual sensor readouts and therefore have multi-

dimension aspects making the data distinct from LLT or Textual observation types. Sources include TIROS Operational Vertical Sounder (TOVS) and Special Sensor Microwave Imager (SSMI) sensors. Raw remote sensor data is generally pre-processed by satellite acquisition software and earth located prior to display or use by METOC decision aid programs.

METOC database imagery data consists of standard format raster display products (e.g., GIF) generated by an analysis or decision aid application. These display products are typically generated by satellite ingest and display, weather forecasting and analysis, or METOC decision aid programs local or external to TESS(NC) systems. The types of imagery products supported include projected satellite imagery, METOC application screen captures, briefing slides, and standard format Internet Web products. Imagery data consists of information describing the characteristics of the data and either the entire standard product or produced "meta"definitions that reference geographic location (region or point), primary datasets, operator annotations, other products, and/or processing routines necessary to regenerate a standard display product.

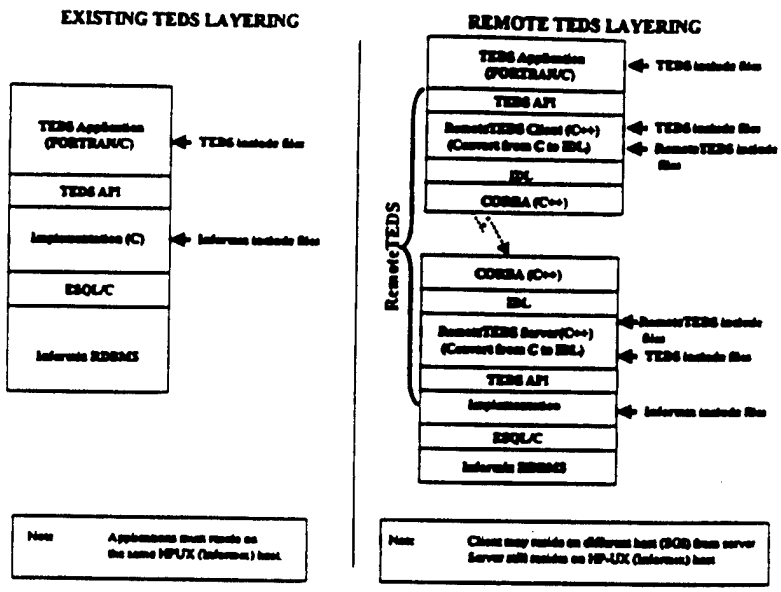
Climatology, which is static data, will have individual data segments for each data type as TEDS matures. Examples of climatology data are Surface Marine Gridded Climatology, Low Frequency Bottom Loss, and Terrain data.

RemoteTEDS

The RemoteTEDS software library provides access to the TEDS database via Common Object Request Broker Architecture (CORBA). RemoteTEDS allows an application to make TEDS API function calls when the TEDS database is hosted on another hardware platform (or even the same system). RemoteTEDS implements the TEDS APIs by passing requests to a CORBA interface. This interface then acts as a transport mechanism replacing that of Informix. More specifically, RemoteTEDS is a layer inserted between the invocation of a TEDS API function call and the processing of that TEDS API function call. RemoteTEDS relies on CORBA as its transport mechanism, utilizing its own set of "wrapper" functions that call the CORBA methods which connect and exchange data to a remote TEDS server. RemoteTEDS was developed by the Naval Research Laboratory, Stennis Space Center, Mississippi, in association with Physitron, Inc. The "RemoteTEDS" CORBA implementation uses Object Oriented Concepts, Inc.'s Object Request Broker (ORB) "OmniBroker."

The motivation for RemoteTEDS is to allow data access via TEDS APIs across platforms without rewriting the TEDS API calls within the application code. This is particularly useful for software applications developers who want to develop and test their code, but do not have access to the full TEDS Informix database. The code can be developed with APIs (which will not change); however, the actual accessing of data will be handled by a CORBA interface. OmniBroker was the freeware CORBA implementation chosen since its C++ was CORBA-compliant.

The following diagram compares the two approaches:



In summary, for each TEDS function call implemented, an equivalent method was required to be written in IDL. Each of the data types used by these functions had to have equivalent IDL data types as well. Once the IDL was written for all of the necessary TEDS methods, corresponding code for the client and a server side of the RemoteTEDS had to be written. The client side (which is the only side the end application programmer sees) must connect to a RemoteTEDS server within the "ted_start()" function, and act as a proxy to the RemoteTEDS server for all TEDS function calls. Here, each of the IDL methods has a C function "wrapper" of the TEDS function call that, in turn, calls its corresponding RemoteTEDS CORBA method (again translating any data structures, if required). The server receives these method invocations, calls the actual TEDS, and returns the result (handling any data conversions necessary).

For example, a TEDS API C function:

```
Int ted_GridRetr( GRIDQUERY, PLINKEDLIST );
```

becomes the IDL method:

```
Interface GRID_API {
..
..
int GridRetr ( idl_GRIDQUERY GridQuery, out idl_GRIDDATAs
GridDataLL );
..
..
};
```

RemoteTEDS IMPLEMENTATION FOR TAMS/RT AT THE NAVAL RESEARCH LABORATORY

Naval Research Laboratory (NRL) Marine Meteorology Division in Monterey, California is currently demonstrating CORBA capabilities under its TAMS/RT (Tactical Atmospheric Modeling System/Real-Time) research project in which meteorological data is being managed by the TEDS database to support TAMS/RT applications programs. Initial trial installations have proven successful in the Fleet. Several individual applications that share data are combined utilizing RemoteTEDS, even though they run on different hardware/software configurations. These applications programs require minimal changes and "incompatible" hardware resources can be networked, incorporating RemoteTeds.

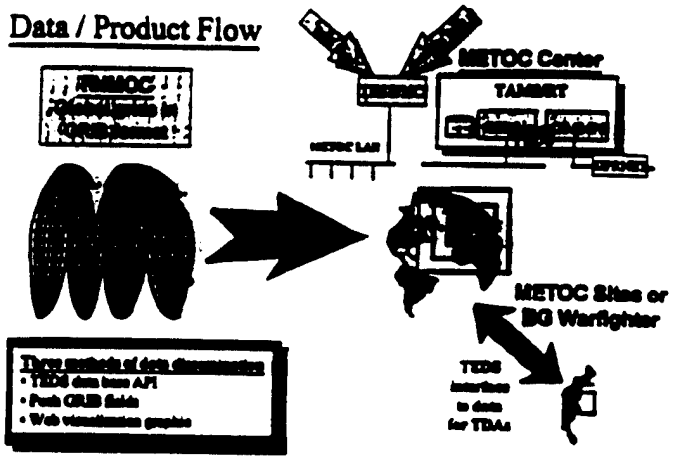
The TAMS/RT is a workstation version of the atmospheric forecast component of the Navy's Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS). COAMPS is a sophisticated numerical model for forecasting clouds, rain, and snow, subgrid-scale mixing, and includes a cloud-interactive radiation parameterization. For the prototype, COAMPS is run on SGI machines. Input data for COAMPS can be retrieved via RemoteTEDS and CORBA from the TEDS database located on a HP J210. COAMPS results are also stored and managed in the TEDS database for use by Tactical Decision Aid (TDA) programs. The motivation for the TAMS/RT is to make the best use of a growing volume of perishable data available on-scene (including local observations, satellite-derived winds and radar). The COAMPS domain is adjustable with grids and output products tailored for individual requirements. Traditional meteorological models provide outputs every twelve hours; COAMPS allows access to results at every time step. The bottom line is more flexible, timely on-scene weather predictions.

RemoteTEDS INSTALLATION

The following procedures were followed to implement the TAMS/RT TEDS API application code with RemoteTEDS:

1. Download Object Oriented Concepts, Inc.'s (OOC) Object Request Broker (ORB) to the required systems. OOC's ORB, currently CORBA-2.0 compliant, is free for non-commercial use. Use README and INSTALL procedures for each specific machine. Install the ORB software on both the server and client machine.
2. Install the RemoteTEDS server libraries on the server machine.
3. Install the RemoteTEDS client libraries on the client machine.
4. On the client machine, modify Makefile for your client application code. Replace regular TEDS library links with RemoteTEDS libraries. Use appropriate flags as specified in RemoteTEDS install procedures. Re-compile application code.
5. On the server machine, set up appropriate TEDS and RemoteTEDS environmental variables (tedsEnvs and REMOTETEDS_IORFILE).
6. On the server machine, Run "remoteTEDS" or "rteds_server". FTP IORFILE file, which has just been created, to the client machine.
7. On the client machine, set up the appropriate RemoteTEDS variable (REMOTETEDS_IORFILE) to point to new IORFILE.
8. On the client machine, run the application code. Data from the TEDS database on the server machine appears on the client machine!

TAMS/RT Technical Concept



TAMS/RT DETAILS

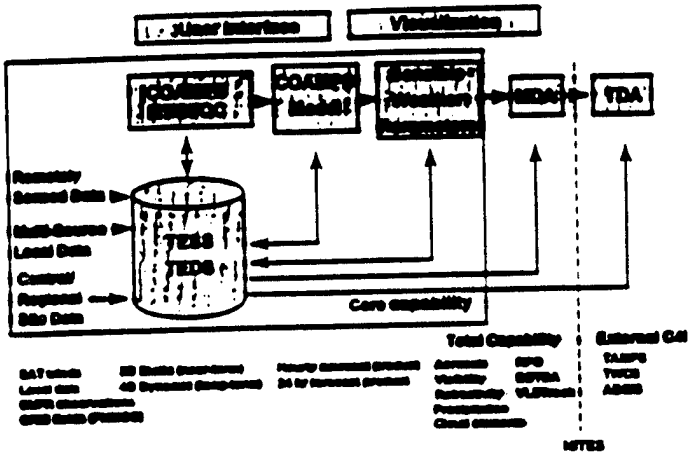
TAMS/RT hardware and software installed at Navy Meteorological and Oceanographic Regional Centers will provide the ability to organically perform very high resolution (up to 3 km) atmospheric analyses and forecasts (out to 36 hours). The forecast output data support decision aids and tactical models that require high fidelity, high-resolution atmospheric data not currently available, such as the Radio Propagation over Terrain model. In addition, TAMS/RT will exploit data sources that may not be available in a timely manner from the main production center, FNMOC (Fleet Numerical Meteorology and Oceanography Center), Monterey, including water vapor and infrared cloud-tracked winds derived from the geostationary weather satellites.

TAMS/RT is an end-to-end, portable, on-scene atmospheric analysis and forecast system. It includes two computer systems, 1) the COAMPS computational server, a multiprocessor workstation with the COAMPS software installed, including data bases of static parameters, such as terrain height, albedo, etc.; and 2) the TEDS database server, a workstation with the TEDS database management system installed. TEDS decodes and quality controls environmental background grid fields received from FNMOC. TEDS provides interfaces for data acquisition and application programs while storing, managing, and making COAMPS results available to other applications over a network interface. This workstation also contains the visualization tools to extract grid fields, satellite derived winds, and conventional observational data from TEDS, to display them on the operator's console for evaluation and diagnostic purposes, and to create and serve graphics for the World Wide Web. In addition, a GUI allows an operator to set up, modify, and automatically execute a COAMPS forecast.

The TEDS database provides data for both MVOI (Multi-Variate Optimal Interpolation) and COAMPS. MVOI atmospheric analysis can use Radiosonde, Surface Observations, SSM/I, SSMT1, Aircraft Reports, Satellite-Derived Winds, TOVS (satellite vertical soundings) data. Output data

generated by MVOI are required inputs for COAMPS. COAMPS requires Bathythermographs, Sh Sea Surface Temperature Observations, SSM/I (ice), Drifting Buoy data, and Multi-Channel S Surface Temperature data. These input data, as well as program output data, are stored in the TEI database.

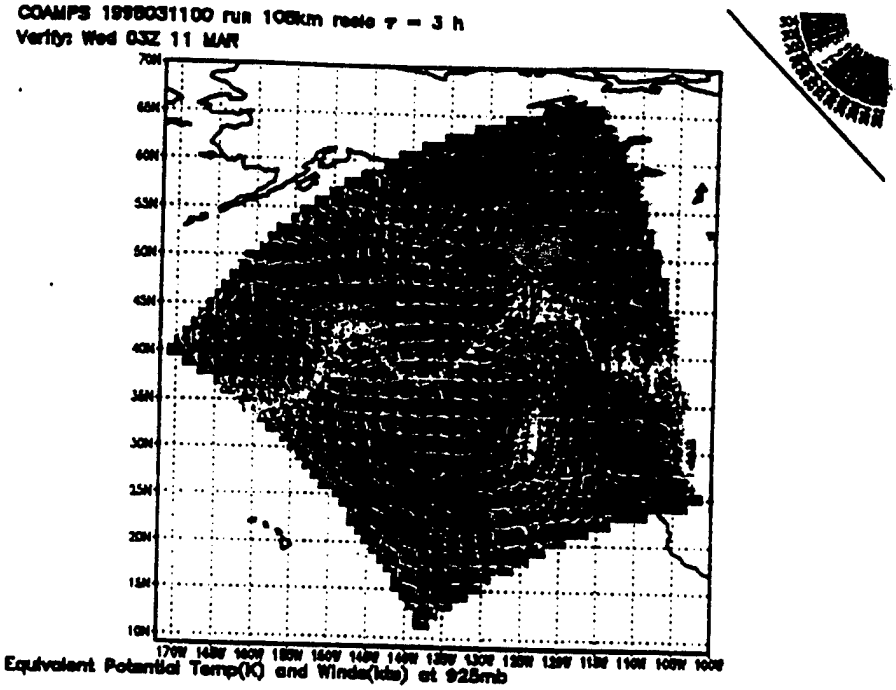
TAMS/RT Forecast Components



TAMS/RT OPERATION

TAMS/RT makes two 36-hour forecasts twice a day, at operator selected times. TEDS recei gridded background fields and boundary conditions from the global model forecast transmitted FNMOC. After waiting approximately three hours past the initial time for observational and satell data to arrive, the COAMPS analysis and forecast can begin and, on the current generation of tacti workstation, takes approximately nine hours for the 36-hour forecast to complete. Thus, the first hours of the forecast cycle are used by COAMPS as it executes. Because the workstation has multi processors, while the forecast is being produced on one processor, the analysis can run nea continuously (every hour) on another processor, using the newly produced forecast fields background conditions and updating them with current observations and satellite derived winds. T output product is then a series of "nowcasts" or analyses of current conditions for the first 12 ho and a 24 hour forecast product spanning the interval between the 12 and 36 hour forecas Intermediate forecast products are available at operator selected intervals as they are computed. Sin the TEDS database manages input and output data, all the products are available for dissemina over the network as data or graphical products, to both users and tactical customers.

The following is an example COAMPS output screen showing temperature and winds for the West United States.



SUMMARY

The TAMS/RT prototype demonstrations have benefited from the use of CORBA. CORBA has proven to be an efficient software development tool for applications developers, particularly in cross-platform situations with legacy code. In the future it is certainly a cost-saving tool, in that it will allow extensive re-use of application code. The use of RemoteTeds and the expanded use of CORBA within the DOD will benefit the government sector, as CORBA is benefiting industry. The design of the TEDS database with APIs was the first step; CORBA (and the Internet) are the next steps in efficient use of resources. The future is bright for software development and re-use.

NOTES:

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Refer to the Naval Research Laboratory, Marine Meteorology Division Web Page at http://www.nrlmry.navy.mil for additional information regarding TESS(NC), COAMPS, and TAMS/RT, as well as other NRL research projects.